Fact Sheet

ATMOSPHERIC ICING ON STRUCTURES

PROBLEM

Every winter, power lines and communication towers collapse in freezing rain storms. The glaze ice load combined with the increased wind load due to accreted ice lead to these failures. Repair costs after a severe storm can be hundreds of millions of dollars. An ice storm in February 1994 that spread from Arkansas to Virginia took down thousands of miles of power lines, leaving some regions without power for four weeks, and caused millions of dollars in damage. Structural engineers need better ice load information to design ice-sensitive structures that are capable of forestalling ice-induced failures but that still are economically feasible.

SOLUTION

The atmospheric icing group at CRREL is working to fill this need. Because ice loads are not regularly measured, we are using historical data at weather stations with ice accretion models to hindcast the accreted ice in past freezing rain storms. We have developed a simple algorithm to calculate the glaze ice load on structural components of different sizes and shapes. In a pilot study in the Midwest, these modeled ice loads are being combined with qualitative ice storm extent and severity information in an extreme value analysis to determine design ice loads. To validate models and build up a database of structural ice loads, our fast-response team surveys ice storms as they occur to map their extent and severity. We are also developing a tower failure database for the United States and Canada. This information will help quantify both the regional severity and the trigger mechanism for tower failures due to wind and ice loads.

Although rime icing occurrences are less widespread than freezing rain in this country, they are often implicated in the failure of tall communication towers. Our field work at the summit of Mount Washington, where severe riming occurs on a weekly basis, has given us a good understanding of the rime accretion process. We used many years of rime measurements to develop a formula for the density of rime ice. We have developed a method for calibrating an off-the-shelf instrument to use at remote sites to estimate the severity of rime icing, and are testing and comparing state-of-the-art instrumentation for measuring the droplet size spectrum and liquid water content in supercooled clouds. We have also undertaken a measurement program to test simple rime accretion algorithms.

Commercially available ice-phobic coatings have been applied to structures to reduce the accretion of atmospheric ice. In our experience these coatings lose their ice phobicity quickly; however, there is no standard method for quantifying the short- and long-term effectiveness of different products. CRREL is developing methods, based on ASTM adhesives test standards, for testing these coatings.

RESULTS

Our freezing rain research is anticipated to lead to an ice load map for the United States for the next revision of the ASCE design load standard. While a similar map for rime ice loads is further in the future, our calibration and comparison of instruments at Mount Washington will give us the tools necessary to determine rime icing severity at particular locations—for example, for wind farms or tall towers. The ice-phobic coatings tests will be proposed as ASTM standard tests and will be used to compare commercially available products.

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